Remote Sensing Support to SEMP

A Series of Tests and Experiments Using Currently-Available Products

(Not all funded through SEMP)

Remotely Sensed Temporal Land Use Data for the Sandhills Ecoregion

As Presented 12 Apr 02
Association of Southeastern Biologists
Boone, NC

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Hunter College

US Army Corps of Engineers®

Engineer Research and Development Center

SEMP & The Sandhills

A goal of SEMP is to transfer technology from the Ft. Benning site to other installations and managed landscapes in shared ecoregions.

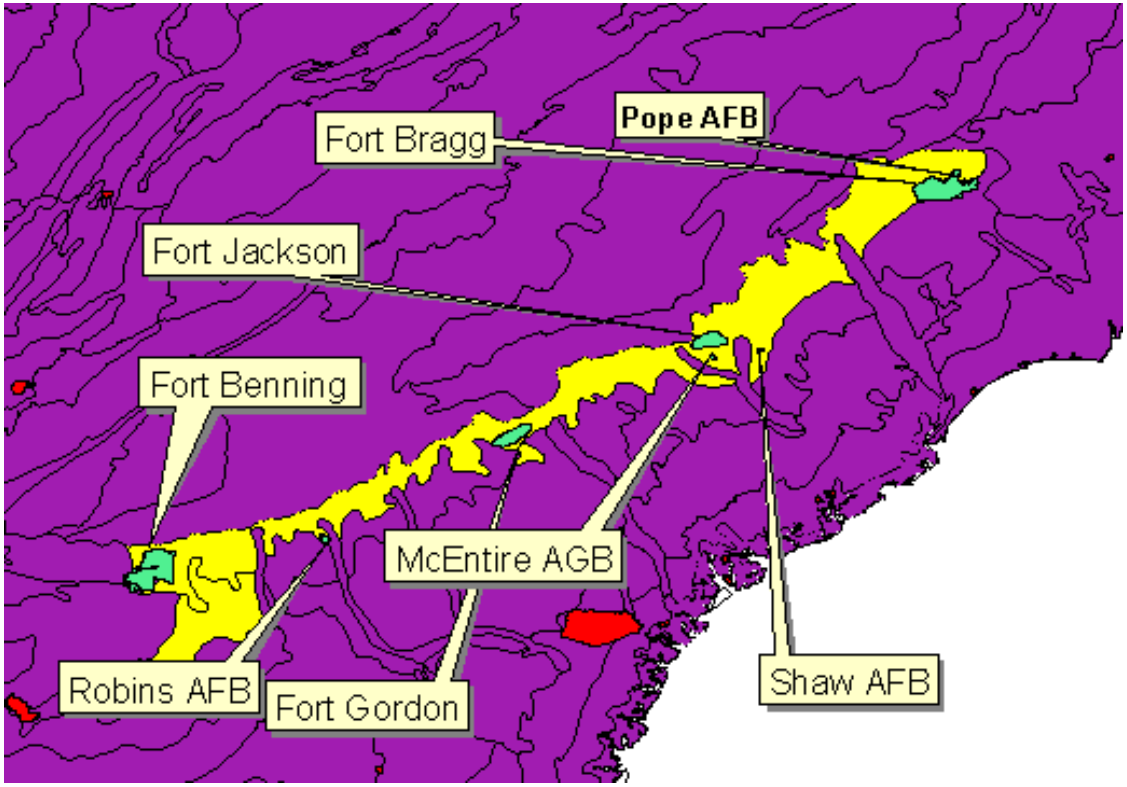
This project's focus is the Fall Line Sandhills region that stretches across Georgia into the Carolinas, just coastward of the Piedmont.

Hunter College staff have developed a unique software algorithm to identify historical land use changes using the North American Land Characterization (NALC) and Multi-Resolution Land Classification (MRLC) data.

A major data set is being refined and made available to SEMP cooperators.

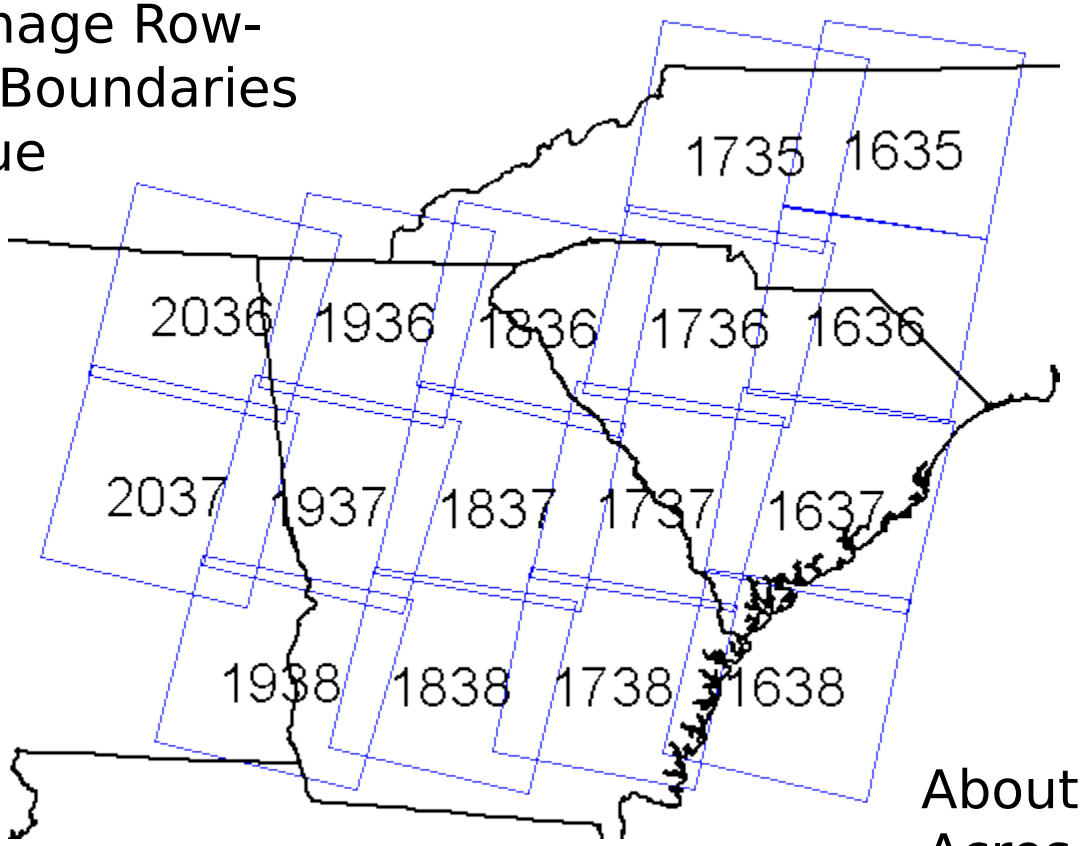
The purpose of the data is to set a standard for monitoring land use changes over a long time horizon.

Sandhills Ecoregion Data Base Setting



Sandhills Ecoregion Data Base Coverage

16 Image Row-Path Boundaries in Blue



About 120 Million Acres Covered at 60 meters resolution.

Data for the Sandhills

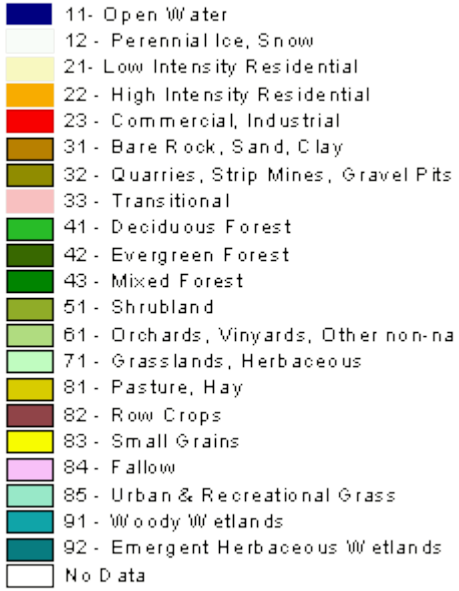
National Land Cover Data – 1990s

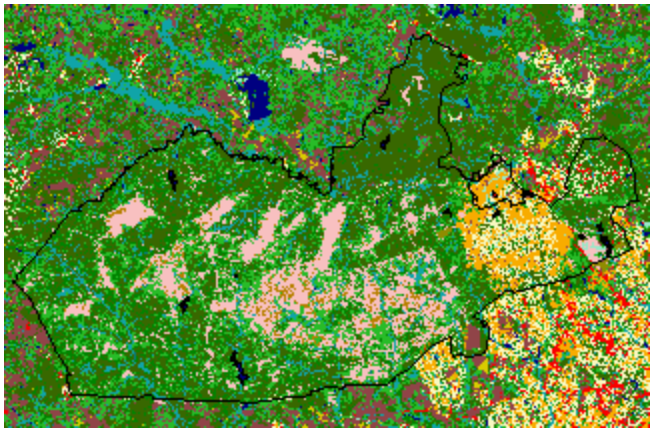
Generated Land Cover data

- 1970's,
- 1980's,
- 1990's,

Contextual data &

Metadata descriptions

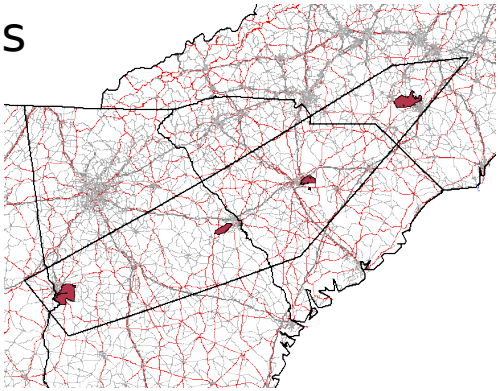

11- Open Water
12 - Perennial Ice, Snow
21- Low Intensity Residential
22 - High Intensity Residential
23 - Commercial, Industrial
31 - Bare Rock, Sand, Clay
32 - Quarries, Strip Mines, Gravel Pits
33 - Transitional
41 - Deciduous Forest
42 - Evergreen Forest
43 - Mixed Forest
51 - Shrubland
61 - Orchards, Vinyards, Other non-na
71 - Grasslands, Herbaceous
81 - Pasture, Hay
82 - Row Crops
83 - Small Grains
84 - Fallow
85 - Urban & Recreational Grass
91 - Woody Wetlands
92 - Emergent Herbaceous Wetlands
No Data



NLCD at Fort Bragg

Contextual Data

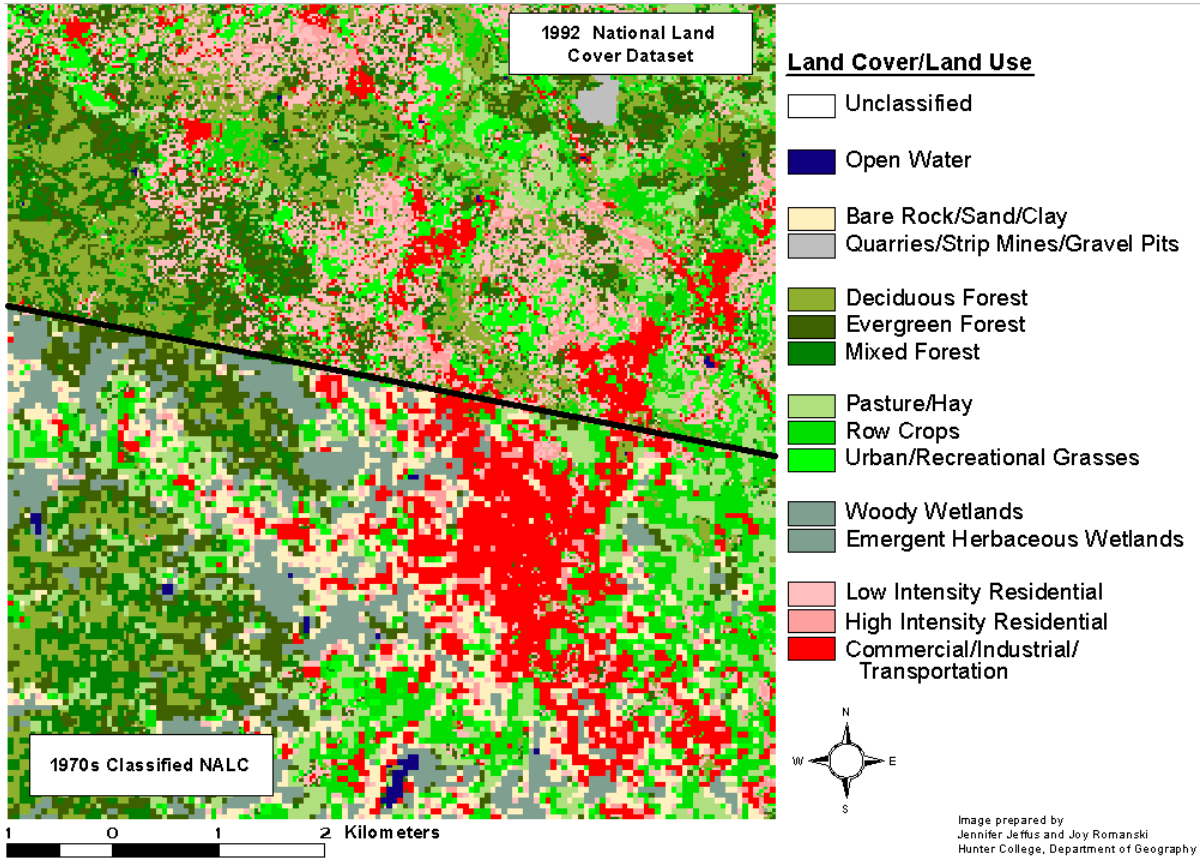
- Watersheds
- Streams
- Aquifers
- States
- Roads
- Ecoregions
  - **Ecoregion, Sandhills**
  - **Ecoregions, Nearby**
- Counties
- County Demographics
- Federal Lands
- Forest Cover
- Forest Fragment Index
- Land Cover
- Land Cover Diversity
- Military Bases
- Monthly Precipitation
- Public Land Survey System
- Urban Areas



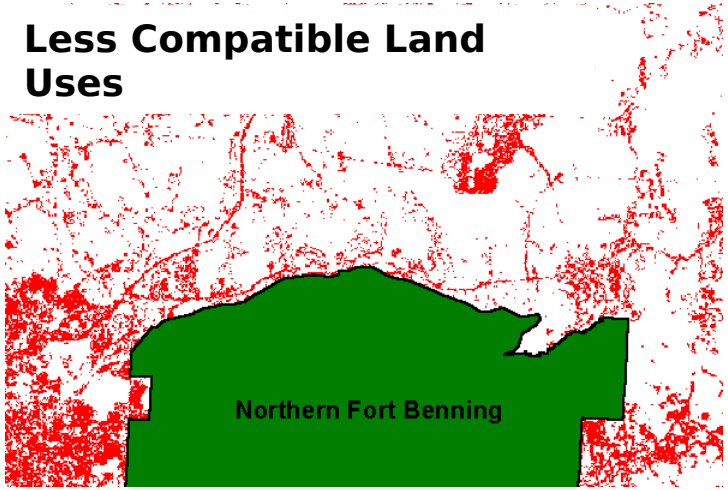
Roads

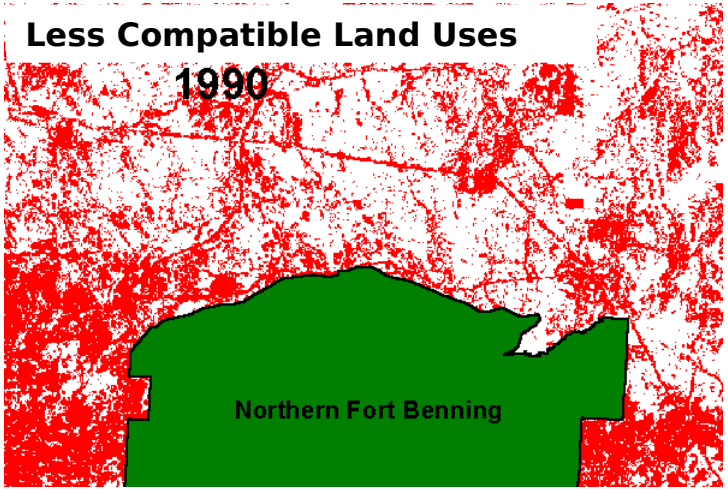
Land Use Change Detection

Rutherfordton, NC - SSE of Asheville. Red and pink are urban land uses. Top part: 30m resolution NLCD "ground truth" data. Bottom: Classified output of the 1970s NALC image (path/row 1836, 60m).

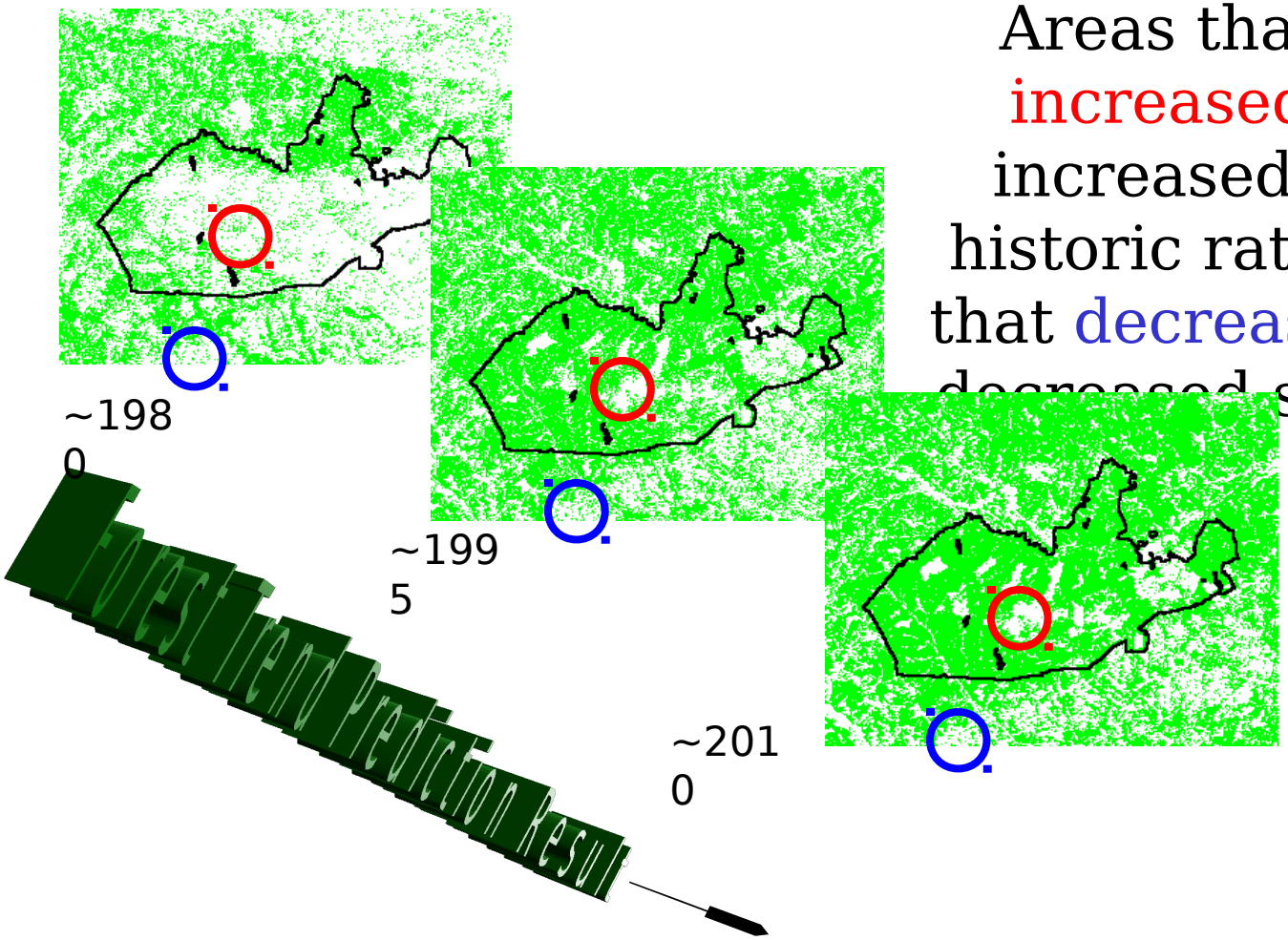


Example Applications





Forestry Change Modeling



Areas that have increased have increased at the historic rate, areas that decreased have decreased similarly.

Historic Corona Satellite Imagery to Support SEMP

A Brief Study Performed in 2nd Qtr FY02

Construction Engineering Research Laboratory (CERL)

U.S. Army Engineer Research and Development Center (USAERDC)

Army Corps of Engineers

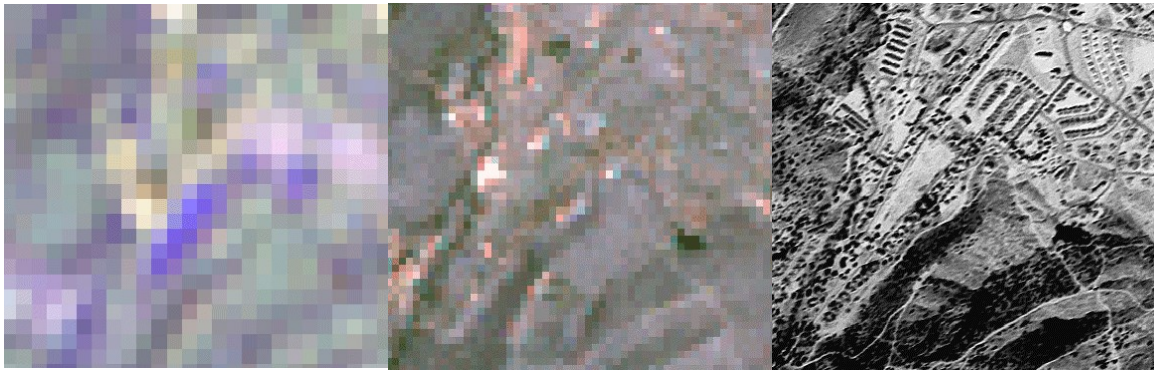
Robert C. Lozar

Background

- **During the Cold War era, massive amounts of remote sensed national defense intelligence data were collected**
- **These data include satellite-based photography**
- **The collected materials and supporting technologies remained inaccessible**
- **Three events have changed the status of these materials.**
  - **early technology has become outmoded**
  - **the breakup of the Soviet Union has removed that country as a major threat**
  - **Presidential Executive Order 12951 (22 February 1995) and initiatives of the U.S. Congress have provided a framework for the declassification of and public access to some of this material.**
- **These photographic and digital images will provide unique opportunities for military land managers.**
- **The intelligence imagery now less highly classified is an archive of the extent and condition of our Federal lands long before other sources of comparable detail were available.**
- **This intelligence archive greatly enhances a land manager's ability to identify changes or identify objects on the land, the locations of which have since been lost**

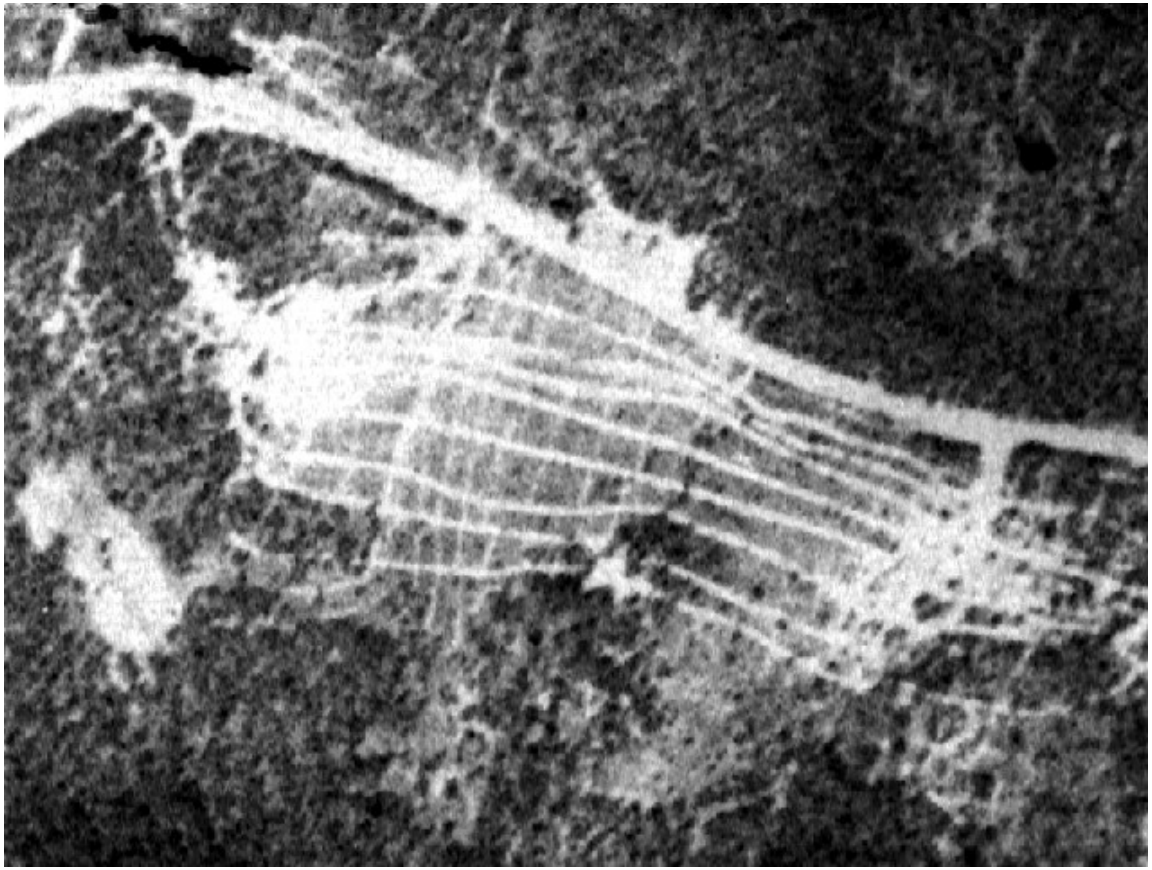
Intelligence vs Civilian Satellite Imagery

1. **Satellites were regularly imaging much of the United States almost from the beginning of their missions (as early as 1959).**
2. **Black and white photographic products of very high resolution from as early as the mid-1960s can be expected to be available for most of the United States.**
3. **Enough data exist that the statement may confidently be made that some images will exist for most installations.**
4. **For many installations without an alternative source of historical imagery, this is a unique archive that is only now available.**



The same area with different sensors: MSS image (left, 1985), TM image (middle, 1997), declassified image (right, 1965).

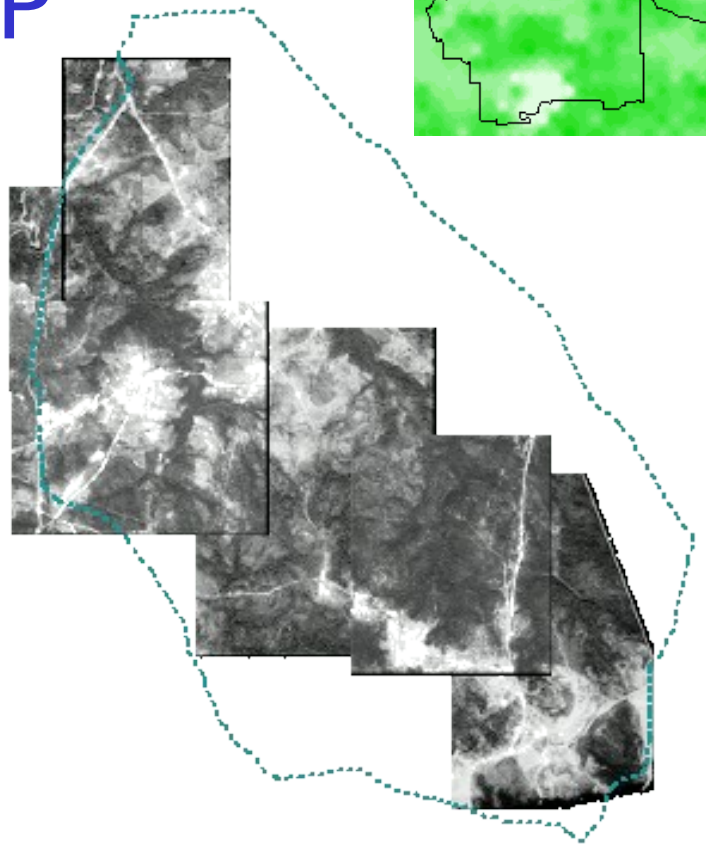
Benning Vegetation Change Example



This 1964 image at Fort Benning, GA, shows tracked vehicle training areas and how a researcher may be able to follow forest edge changes.

For SEMP

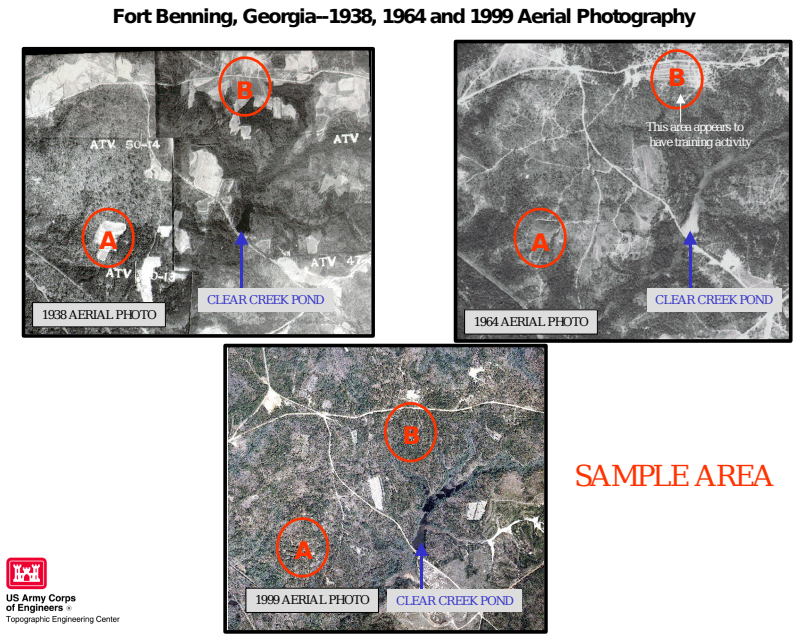
1. A historical record gap exists for the 1960s at Fort Benning (ERDC/TEC is developing a 1938 imagery map from air photos and satellite images are available beginning in 1972 with LANDSAT MSS)
2. Since ERDC/CERL had some Corona imagery from another project, we asked if SEMP researchers would be interested in testing the 1964 image of Fort Benning.
3. Of the seven research teams, five (including TEC) expressed interest in receiving a sample.
4. Twelve samples were sent out.



Several image samples were made available. Many were focused in Training Compartment D.

Researcher's Comments

1. **All respondents agreed the images are/would be useful.**
2. **Several requested more, or images outside of the coverage on hand.**
3. **ERDC TEC is using the 1964 sample to show changes in compared to the 1938 and 1999 air photos (to the right).**
4. **SREL did a detailed comparison of vegetation changes between 1964 and 1999 images (next slide).**



ERDC/TEC (Frano) Comparisons

Researchers' Comments

SREL Application (B. Collins)

The two test images contained 9 SREL plots (each ca. 100 m x 100 m) in the D compartment. These are most of our "heavier" military disturbance plots.

The images were classified into three categories: forest, shrub/grass, bare ground, and plots were overlayed. Table 1 shows the classification results, as well as current vegetation (canopy, understory, canopy richness, proportion of pine), amount of disturbance features, and soil texture of each site.

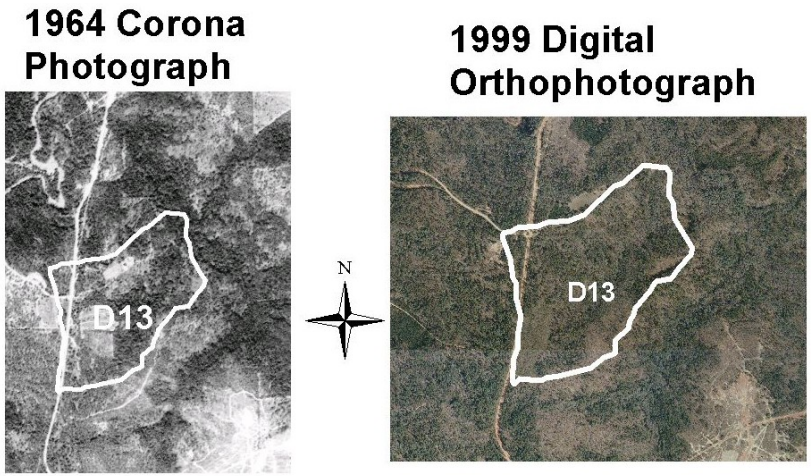
In general, the SREL D compartment sites have changed from open sites in 1964 to forests that vary from hardwoods to loblolly, short leaf, or longleaf pine dominance. There is no apparent relationship between current plot vegetation composition and forest cover in 1964, but species composition of the 1964 forest or shrub/grassland could not be determined from the photo.

	1964			Current					
Plot	Forest	Shrub/Gr	Bare	Canopy	Understory	Disturbance	%Clay	Richness	%Pine
d14a	28.38%	27.65%	43.97%	LB,LL	CA,QU	211.48	4.6	13	55
d14b	73.07%	21.54%	5.39%	LB	RHS,PI	41.59	4.7	12	96
d14c	29.75%	43.86%	26.39%	SL,LB	QU,AND	127.41	6.6	8	95
d16a	41.34%	57.42%	1.25%	LL	POA,PTER	272.06	20.1	6	99
d16b	48.99%	51.01%	0.00%	LL	POA,CNID	150.37	4.5	9	87
d16c	34.63%	53.59%	11.78%	LB,LL	POA,AND	238.44	15.7	6	99
d16d	34.63%	53.59%	11.78%	LB,SL	POA, HET	220.07	18	5	77
d16e	76.11%	23.89%	0.00%	QA,CSP,SL	SMI,PTER	189.28	25	17	21
d16f	99.00%	1.00%	0.00%	LB	AND,PTER	147.35	26	8	96
d16g	0.00%	10.85%	89.15%	LB,SL	POA, HET	302.62	11	8	75

Researchers' Comments

ORNL Application (P. Mulholland)

We are currently using the 1964 Corona images to determine the land use history of our study watersheds. The images show the same watershed overlain on the 1964 Corona photograph and the 1999 digital orthophotograph. Different land use patterns and possible disturbances are evident between the images. This may be valuable information in discerning disturbance impacts during the data analysis phase.



ORNL (Mulholland) Comparisons

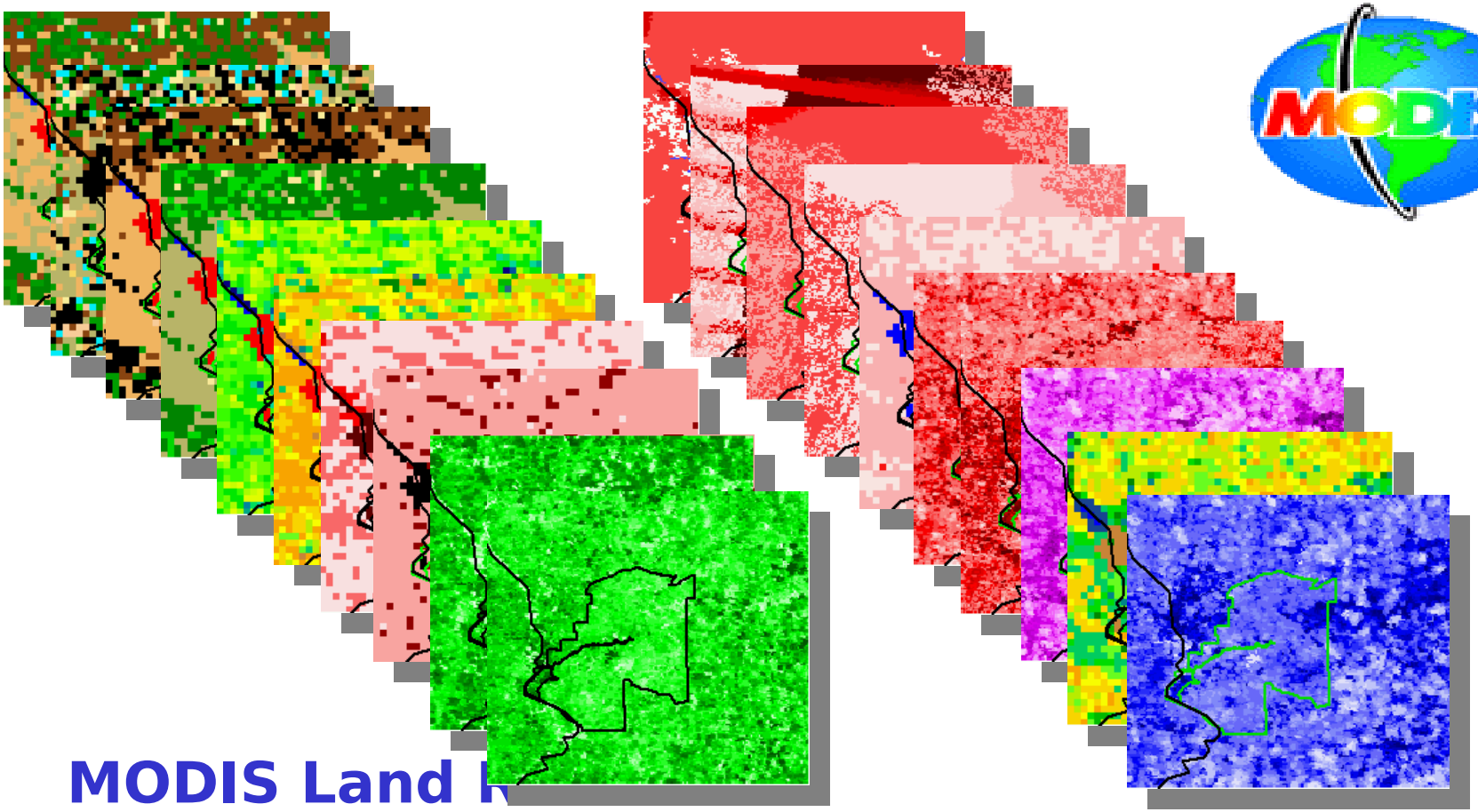
Conclusions & Recommendations

Conclusions:

- **Most research groups were anxious to see the imagery.**
- **All groups concluded that it was or could be useful.**
- **Some groups showed how useful it could be in a statistical evaluation or to show changes over time.**
- **Fills in a time gap in higher-resolution coverage**

Recommendations:

- **Proceed in acquiring the missing portions of Fort Benning and reformatting into a complete coverage that can be made available to researchers via the SEMP repository.**
- **Develop a land cover/ vegetation map from the imagery in coordination with TEC and other SEMP research groups.**



MODIS Land R
Sensing Imagery & Derived Products for the SEMP Data Repository

Robert Lozar
ERDC-CERL

April 2002

SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

US Army Corps of Engineers®

Background

- **NASA Launched (Dec 1999) the first of the Mission To Planet Earth (MTPE) Satellite Platforms-Terra 1.**
  - **Several of the instruments provide data of interest to Land Managers – MODIS, MISR and Aster**
  - **Products derived from the instruments are:**
    - Interrelated (e.g. atmospheric instruments provide data to correct for atmospheric effects in land sensing instruments – never available before)
    - Products may be built from a series of steps using different instruments
    - Products will be available on a regular basis for most of the earth over at least the next 15 years

Science

Products derived from the MTPE are Physical Process Based

- Scientifically based on 1st Principal Physical Processes
- Objectively derived
- Calculated and Repeatable

– **Cutting edge science**

– **Inexpensive to obtain and manipulate**

– **Products are temporally available**

- weekly, monthly or yearly (varies by product)
- Over a period of at least 15 years into the future
- Often coordinated with products 30 years in the past
- Therefore excellent Ecological monitoring over nearly 5 decades

SEMP

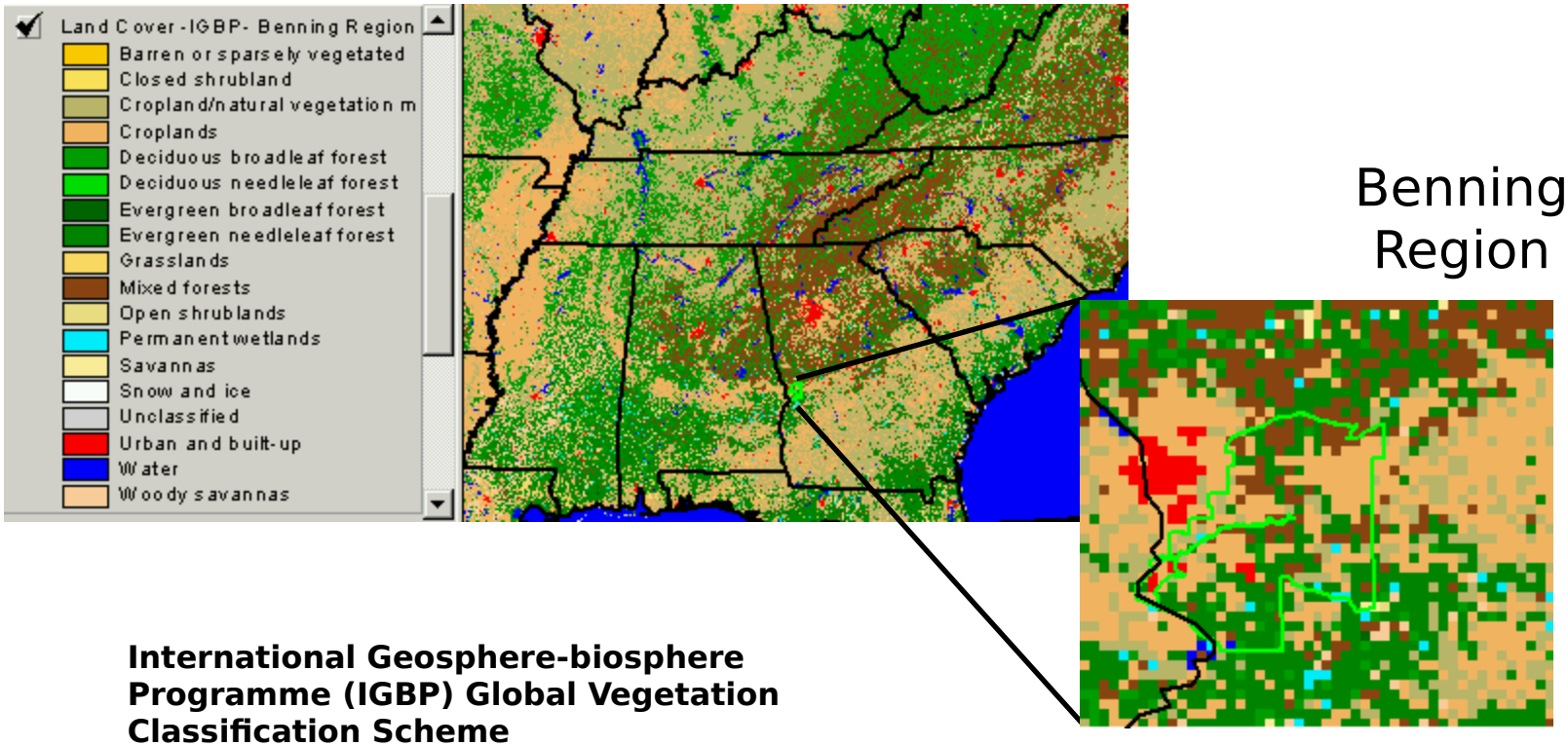
The November 2001 Technical Advisory Committee (TAC) meeting, developed an action item (4.c) regarding the accession of MODIS products for integration into the SEMP Data Repository.

PRODUCTS Identified to be accessed were:

<u>Product ID</u>

- **MOD12 Land cover/Land cover change**
- **MOD13 Gridded vegetation indices (Max NDVI & Integrated EVI)**
- **MOD15 Leaf area index & FPAR**
- **MOD17 Net Photosynthesis and Primary productivity**
- **MOD44 Vegetation cover conversion**

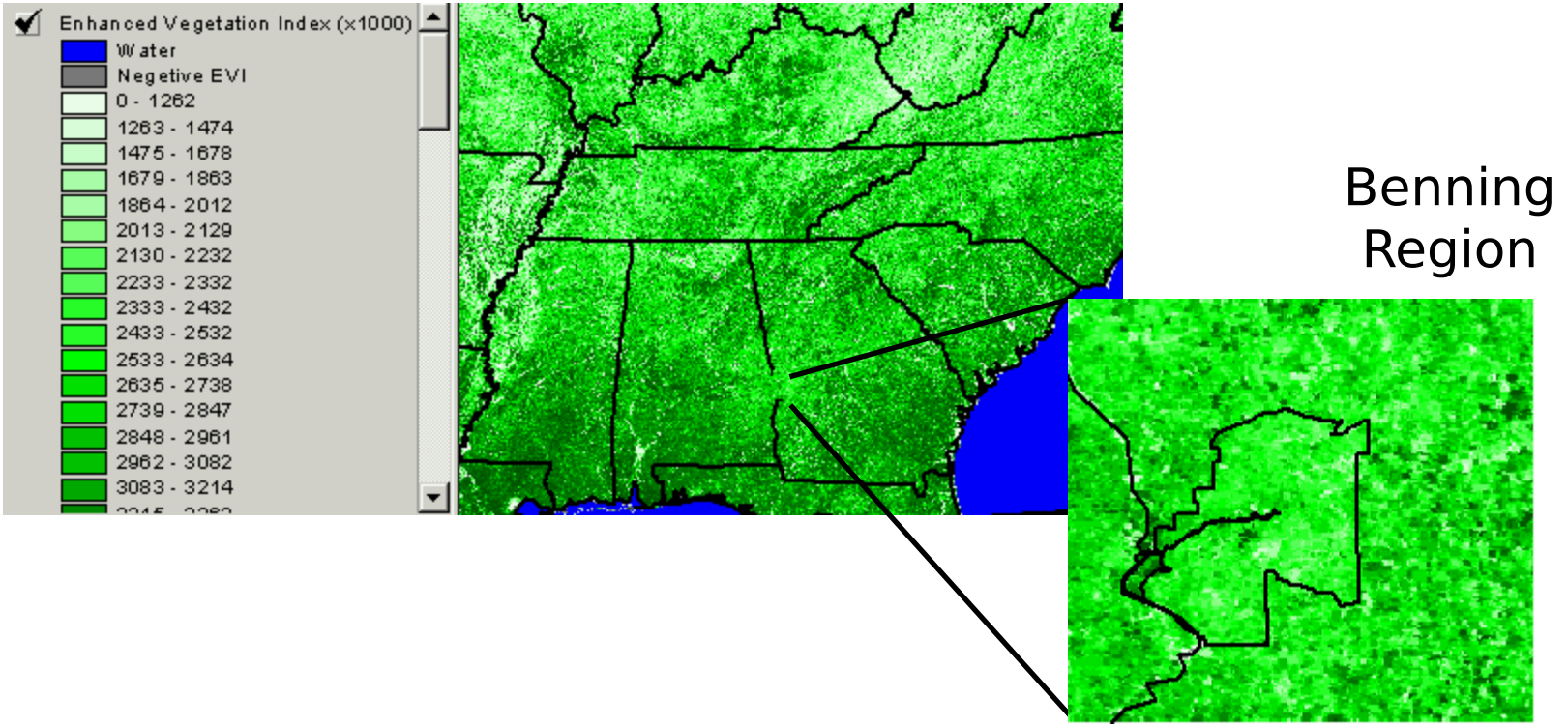
Example Derived Product– IGBP Land Cover



International Geosphere-biosphere Programme (IGBP) Global Vegetation Classification Scheme

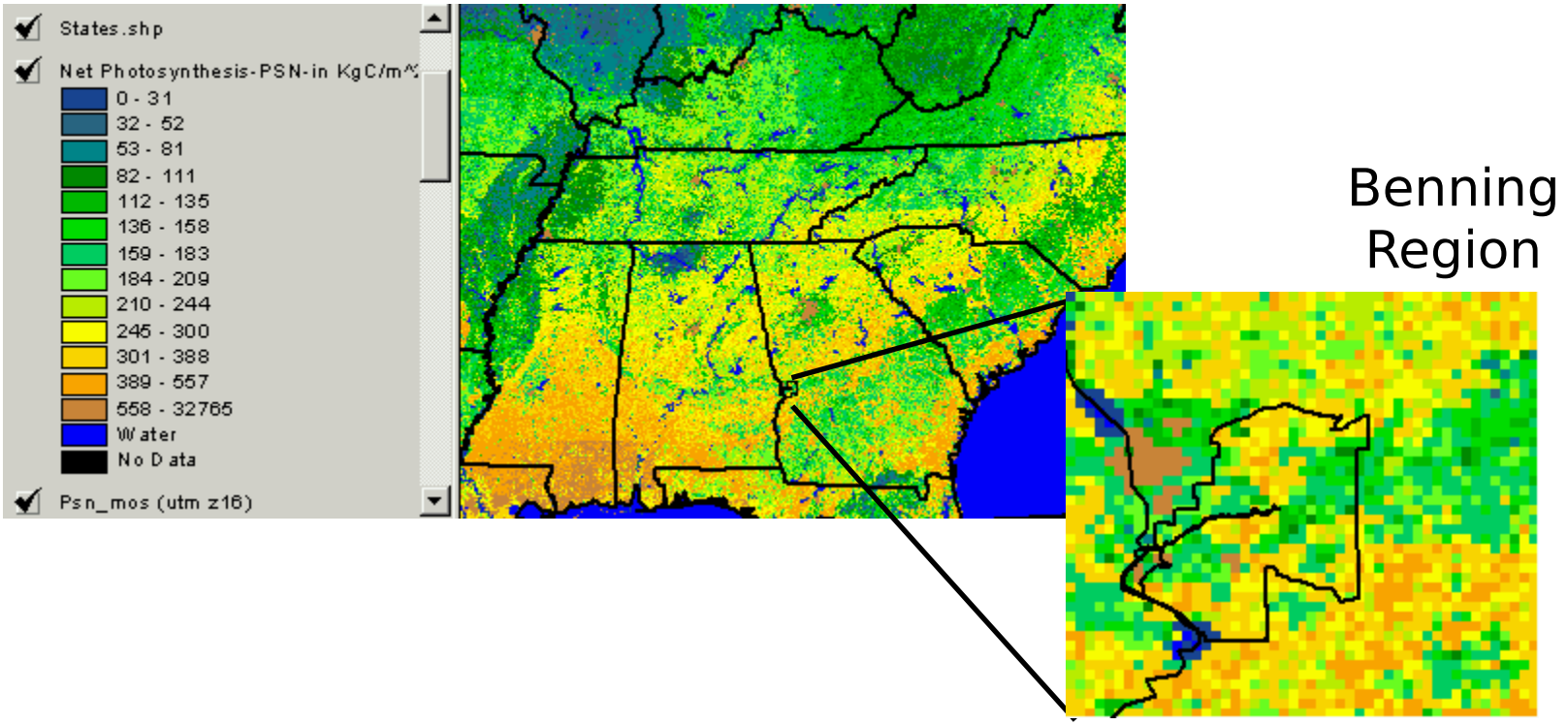
MODIS Data Set: MODIS/Terra Land Cover 96 Day L3 Global 1 km ISIN Grid
Date: 3 Months ending 2001-01-16 Resolution: Original: 926.6254 Reprojected: 1339.2966 meters

Example Derived Product – Enhanced Vegetation Index (EVI)



MODIS Data Set: MODIS/TERRA VEGETATION INDICES 16-DAY L3 GLOBAL 250M ISIN GRID V003
Date: 16 days ending 2001-03-06 Resolution: Original: 231.6564 Reprojected: 334.8242 meters

Example Derived Product – Net Photosynthesis (PSN)



MODIS Data Set: MODIS/TERRA NET PHOTOSYNTHESIS 8-DAY L4 GLOBAL 1KM ISIN GRID V003
Date: 8 days ending 2001-03-14 Resolution: Original: 926.6254 Reprojected: 1339.2966 meters

Application Examples

1. Using Landscape Ecology Indices

The generation of these indicators can be a complex, lengthy undertaking, requiring substantial GIS-expertise.

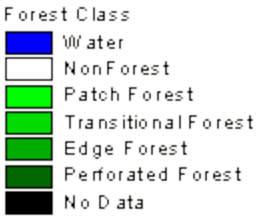
The U.S. EPA Landscape Ecology Branch (Las Vegas) in cooperation with Region 4 and TVA are developing a user-friendly interface to facilitate this process. It is called ATtILA.

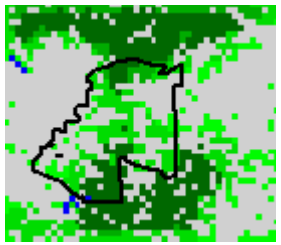
ATtILA (Analytical Tools Interface for Landscape Assessments) calculates many commonly used landscape indicators.

It is suitable for landscapes from deserts to rain forests to urban areas.

Application 1: Landscape Characteristics Output From ATtILA Using the MODIS Land Cover File

Forest Fragmentation Class





	Percent in Forest Patch Class	Percent in Forest Transition Class	Percent in Forest Edge Class	Percent in Forest Perforated Class	Percent in Forest Interior Class
FORT BENNING	6.4171	26.4706	3.7433	16.5775	0
Not Fort Benning	9.4138	14.0924	5.5242	18.9966	0
Comments	Benning contains 1/3 less tiny patches	Benning contains about twice the transition forest class	Benning contains 1/2 the edge areas	Roughly equal	No Extensive areas of forest anywhere

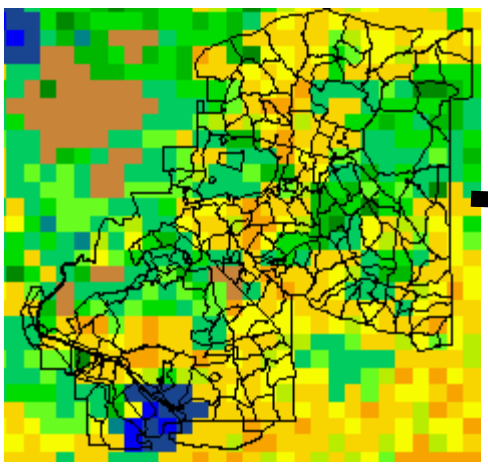
Forest fragmentation is classified into five categories: patch, transitional, edge, perforated and interior.

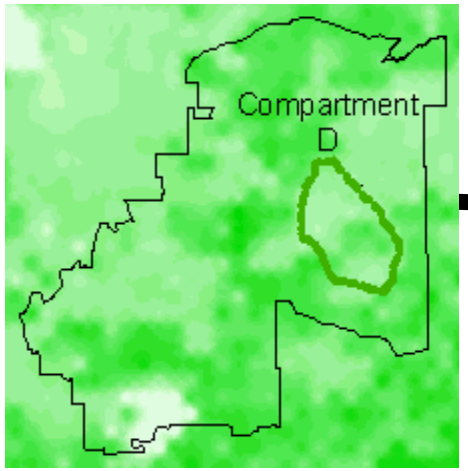
Done at ERDC/CERL

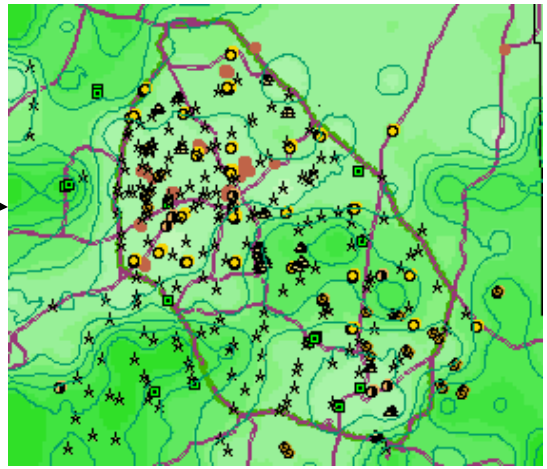
From the table and spatial data:

There are larger and more extensive patches outside of Benning. Those inside of Benning are part of the regional pattern. Most of the Benning forest is already in the transition class, meaning it has already been converted to a highly fragmented status.

Application 2: Physical Characteristics Manipulation Using the MODIS Net Photosynthesis File in a GIS Evaluation



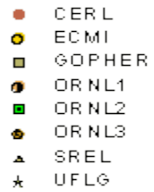




PSN Product Smoothed

Done at ERDC/CERL

Extract Compartment D & overlay SEMP Sites



Project_id	Count	Ave_Contour	Min_Contour	Max_Contour	StdDev_Contour
CERL	61	150.819	150	200	6.4018
ECMI	68	175.737	150	300	41.871
ORNL1	12	195.833	150	300	68.9477
ORNL2	18	225	150	350	71.2287
ORNL3	22	211.363	150	300	59.6255
SREL	64	209.375	150	300	60.3396
UFLG	192	197.656	150	350	67.3525

How do the sites compare by research group? From the Table, CERL sites have lower NPS and vary significantly less than others. ORNL2 has chosen sites that are in general highly productive, followed closely by ORNL3 and SREL.

Recommendations

The MODIS products are just becoming available. More will appear as production moves toward the yearly products, which will often be of the most interest to land managers. Therefore:

- **Continue Collecting these as they become available, document and present their usefulness to managers.**
- **Assess another date so comparisons can be made**
- **Use this data set to analyze characteristics. E.g.**
  - Run spatially based indicator evaluations such as EPA's ATtILA or fragmentation analyses on this data
- **Use additional data to monitor health over time. While developing this work, it was noted that EVI was significantly different inside the installation boundaries than outside. This was not reflected in the more well known, standard but not scientifically refined NDVI.**